Coupled Physical Oceanography and Acoustics Observations in the Asian Marginal Seas

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LONG-TERM GOAL

My long-term goal is to enhance our understanding of coastal oceanography by means of applying simple dynamical theories to high-quality observations obtained in the field. My primary area of expertise is physical oceanography, but I also enjoy collaborating with biological, chemical, acoustical, and optical oceanographers to work on interdisciplinary problems. I collaborate frequently with numerical modelers to improve their predictive capabilities of Navy-relevant parameters in the littoral zone.

OBJECTIVES

The objective of this program was to find, obtain, and analyze historical oceanographic data from the South China Sea (SCS) to help plan a major ONR field program in the region during FY00-01. The objective of the field program is to understand how the complex littoral environment (i.e., its water column, boundary, sediment and sub-bottom structure and inhomogenities) affects the ray paths, mode structure, propagation loss, and temporal and spatial (both vertical and horizontal) coherence for low-to-intermediate frequency (50-4000 Hz) acoustic transmissions in shallow water. Parameters deemed useful for this study include the strength, location, and variability of the dominant T, S, and density fronts, the strength and seasonal variability of the vertical stratification, the structure of the alongshore currents over the continental slope, and the nature and frequency of the Kuroshio intrustions.

APPROACH

A search for historical data in the South China Sea was conducted which included the published literature, the National Oceanographic Data Center (NODC), the Navy's Master Oceanographic Observations Data Set (MOODS), and other oceanographic archives. A number of useful data sets were found. These cruises used modern instrumentation manufactured by Sea-Bird, NBIS, and RD Instruments and had station spacing condusive to a successful analysis. This is a general report due to restrictions on some of the data sets. The detailed results have already been presented to ONR program managers during a seminar at ONR headquarters.

WORK COMPLETED

Following some additional quality control, the CTD station data were loaded into MATLAB and analyzed with a package assembled by the PI. Some programs were written from scratch and others nested on previously existing MATLAB toolboxes made available by WHOI, CSIRO, and USGS.

Horizontal cross sections and contour plots at various levels were made for the temperature, salinity, and density fields. The predominant water types for the shelf, slope, and Kuroshio intrusion were identified from the literature. Temperature-salinity (TS) plots were used to trace the evolution and mixing of these water masses within the sea.

The ADCP data were studied using a combination of the University of Hawaii CODAS processing system and the various MATLAB toolboxes. The reanalyzed data were rotated into along- and across-shore coordinates and plotted on new geographical scales to match the CTD data. Both vertical cross-sections and vector plots on pressure surfaces were produced to show the dominant current patterns present during each cruise.

RESULTS

1. The near-surface T and S surfaces (25 and 50 dbar) in the NW SCS were dominated in springtime by an energetic mesoscale eddy field, which contains eddies of both signs with length scales typically order 100 km, and thermocline displacements of order 20 m at 50 m depth. The thermocline was shallow with maximal strength between 50-100 m.
2. The strongest currents exceeded 100 cm s^{-1} and were associated with what looks like a cold core eddy near the SCS entrance at the Luzon Straits. This feature has thermocline displacements order 100 m from 100 to 400 m centered approximately on 250 m. Given its identical position in both years, the feature appears trapped by topography. An alternative explanation of this feature is that inflowing and outflowing Kuroshio water is split by a subsurface ridge in this region and it just looks like an eddy. More data are needed to resolve this feature.
3. The T and S cross-sections all show a very clear, subsurface salinity maximum centered near 150 m depth, > 34.8 psu near the Luzon Straits decreasing to > 34.6 psu towards the southwest along the continental slope. This water can only be of North Pacific origin (Qu et al., 1999) and appears to flow continuouslySW along the slope.
4. There is no sign of the South China Sea Warm Current (Chao et al., 1995) flowing towards the northeast in any of the data sets.
5. Very strong salinity fronts are common. Sometimes the fresh water is towards the coast, similar to the New England shelf, and other times it is offshore with the saltiest water near the coast.
6. The freshest surface water is also the warmest and appears to enter the region from the southwest, around Hainan Island from the Gulf of Tonkin and the Vietnamese coast, rather than from the Pearl River outflow.
7. Items 3 and 6 above combine to form a salinity gradient decreasing from NE to SW along the Chinese continental shelf.
8. The interannual variability is phenomenal. The surface salinity is everywhere 1.0 to 1.5 psu lower during 1997 than 1998, due to a massive influx of warm, fresh water from the south, which was completely absent in 1998. The Taiwan Straits inflow was also much less evident in 1997 than 1998, when it introduced water of 16 ºC and < 30 psu into the NE corner of the sea. Subsurface currents during 1997 were much more organized that 1998. There was a clear SW coherent flow during 1997 and a confused eddy field in 1998.

IMPACT/APPLICATION

The analysis of these new data sets revolutionized our view of the shelf circulation in the South China Sea. Previous data sets made available by the People's Republic of China and the former Soviet Union consisted mostly of old bottle casts with insufficient horizontal and vertical spacing to resolve the

current structures of interest. These cruises contained no velocity data of any kind. Most of the MOODS data base was XBT data from the Vietnam war era, which could not illuminate the salinity or density structure. A much more sensible field program for the South China Sea is being designed based on the results of this analysis.

TRANSITIONS

None.

RELATED PROJECTS

1 – Current observations over the continental slope off the Farallon Islands (with C. A. Collins, NPS, and M. Noble, USGS, EPA sponsorship). Three moorings, 14 current meters, one year, to examine advection and dispersal at the EPA deep water dumpsite.

2 – The Innovative Coastal-Ocean Observing Network (ICON). Integrated observations, data assimilation, and modeling of the currents and hydrography in and around the Monterey Bay. (with J. D. Paduan, L. K. Rosenfeld, N. Garfield, C. A. Collins and C.-S. Chiu, NPS, plus seven other partners, NOPP funding).

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PUBLICATIONS

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